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ABSTRACT

This is one of eighteen sets of individualized mathematics problems developed by the Oregon Vo-Tech Math Project. Each of these problem packages is organized around a mathematical topic and contains problems related to diverse vocations. Solutions are provided for all problems. Problems in this volume require the computation of square roots, primarily in the context of using the Pythagorean Theorem. Problems are drawn from the vocational areas of electronics, industrial, electrical, and hydraulics technology, forestry, auto mechanics, and construction. (SD)

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I
L INDIVIDUALIZED
LEARNING
S SYSTEMS

Individualized Math Problems in

Square Root

Oregon Vo-Tech Mathematics Problem Sets

Retrieval - Dissemination Center
Oregon Board of Education
942 Lancaster Drive N.E.
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Individualized Learning Systems

MATHEMATICS

Square Root

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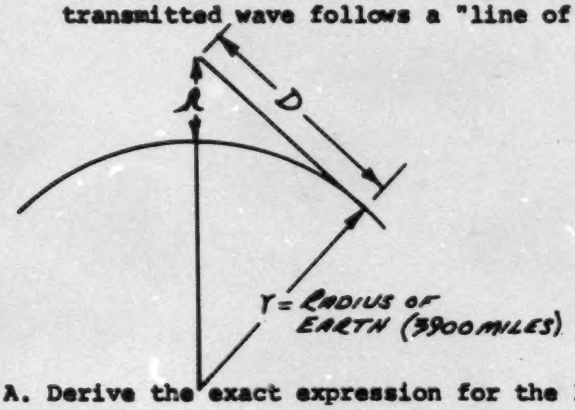
A. Problems with solutions.

1. Microwave energy travels in a straight line after leaving a transmitting antenna, and is rarely reflected by the ionosphere. Thus, the transmitted wave follows a "line of sight" rule as illustrated below:



Where D = "line of sight" distance in miles

r = radius of earth in miles

h = transmitting antenna height in miles.

A. Derive the exact expression for the line of sight distance, D.

B. If your citizens' band microwave antenna is located at 1000' above sea level and there were no obstructing mountains to interfere, how far could the signal be received by a receiving antenna at sea level?

Solution:

A. By Pythagorean Theorem:

$$(r + h)^2 = r^2 + D^2$$

$$D^2 = (r + h)^2 - r^2$$

$$D = \sqrt{h\ (h + 2r)}$$

B. $h = \left(1000\ \text{ft} \times \frac{\text{mi}}{5280\ \text{ft}}\right) = 0.189 \text{ miles}$

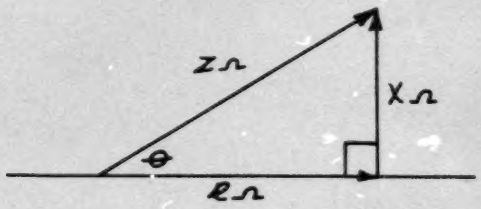
$D = \sqrt{0.189 \text{ miles}\ (0.189 \text{ miles} + 7800 \text{ miles})}$ omitting the 0.189 term:

$D = \sqrt{0.189 \text{ miles}\ (7800 \text{ miles})} = 38.4 \text{ miles}$

SQUARE ROOTS
Level I

B. Problems without solutions.

2. Impedance, Z, is the alternating currant equivalent of resistance. Contrary to resistance, which simply dissipates power, impedance also introduces a phase shift, θ, between the applied voltage and the induced current. It is customary to deal with impedance in terms of its resistive component, R, and its reactive component, X, which are always at right angles to each other. The magnitude of the impedance is the hypotenuse of this triangle and the phase angle, θ, is as indicated below:

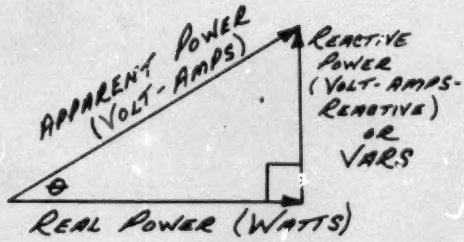


For a circuit containing a resistance of 300 OHMs and a reactance of 125 OHMs:

a. Find the impedance, Z.
b. Graphically determine the phase angle, θ.

B. Problems without solutions.

3. In AC circuits containing resistance, R, and either inductive reactance, X_l , or capacitive reactance, X_c , the equation for power used in DC applications (P = VI) cannot apply due to the phase angle, θ , between the voltage and current in the circuit. For instance, if you were to measure the voltage applied to a motor (containing resistance plus inductive reactance), and the current drawn by the motor, their product VI would give apparent power. In actuality, the motor would be consuming less power than measured. The relationship between the power components is illustrated below:



Where: Real Power is the power dissipated by the motor resistance and the load.

Reactive Power is the power stored and returned by the inductance of the windings.

Apparent Power is the power measured as VI.

θ is the phase angle of the circuit.

If the measured voltage is 220 volts; the measured current is 1.5 amperes and a wattmeter shows the real power consumed to be 186 watts (1/4 horse-power), find the reactive power.

Complete solutions to B problems.

2. a) By the Pythagorean theorem :

$$Z^2 = R^2 + X^2 \; ; \quad Z = \sqrt{R^2 + Z^2} = \sqrt{300 \text{ OHMs} + 125 \text{ OHMs}} = 325\,\Omega$$

$$Z = 325\,\Omega$$

b) By graphical plot:

$$\theta = 22.6^\circ$$

3. Calculate Apparent Power = VI = (220)(1.5) = 330 Watts
by Pythagorean Theorem: $(\text{Apparent Power})^2 = (\text{Real Power})^2 + (\text{Reactive Power})^2$.

$$330^2 = 186^2 + (\text{Reactive Power})^2$$

$$\text{Reactive Power} = \sqrt{330^2 - 186^2} = 272.6 \text{ Volt-Amps-Reactive}$$

$$\text{Reactive Power} = 272.6 \text{ VARs}$$

B. Problem with Solutions

1. Which is larger in cross-sectional area and by how much in CM (circular mills), an AWG no. 6, 7 strand wire conductor with each strand having 0.0612 in diameter or an AWG no. 6, single strand conductor having a diameter of 0.187 in?

   Note: Area in circular mills = (diameter in Mills)
   1 mill = 0.001 inch

1. AWG no. 6, 7 strand

Area in CM = (7)(61.2) = 26,250

AWG no. 6, single strand

Area in CM = (184) = 33,856

Thus #6 single strand is larger by;

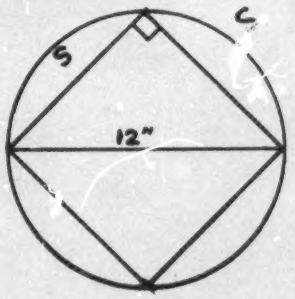
33,856 CM
- 26,250 CM
7,606 CM

SQUARE ROOT
Level II

Forestry

A. Problems with complete solutions.

1. Consider a circle of diameter 12 inches to represent the cross section of a log.



a) Find the dimensions of the largest square beam that can be sawed from this log.

b) The 4 segments wasted are called slabs. What per cent of the cross sectional area is wasted? ($A=\pi r^2$).

Solution:

a) We consider 12 in to be the hypotenuse of a right triangle with equal legs (S) and apply the pythagorean theorem.

$$S^2 + S^2 = (12 \text{ in})^2$$

$$2S^2 = 144 \text{ sq in.}$$

$$S^2 = 72 \text{ sq in.}$$

$$S = 8.49 \text{ inches}$$

$$S = \sqrt{72 \text{ sq in.}}$$

b)

Area square $= (8.49)^2 = 72$ sq in.

Area circle $= \pi r^2 = (3.1416)\left(\frac{12\text{in}}{2}\right)^2 = 113.1$ sq in.

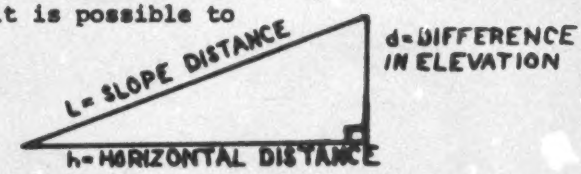
waste = 113.1 sq in - 72 sq in = 41.1 sq in.

$$\% \text{ waste} = \frac{41.1 \text{ sq in.}}{113.1 \text{ sq in.}} = .36 = 36\% \text{ waste from slabs.}$$

A. Problems with solutions, continued.

2. In measuring the distance betweent two points on a slope it is often impossible to obtain a direct measurement. Using the diagram below and the pythagorean theorem it is possible to obtain an indirect measurement.

Solve the following:

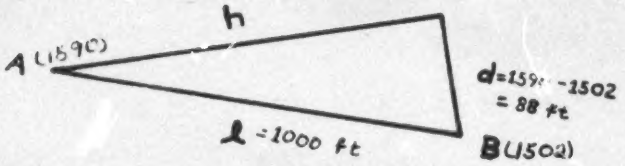


a) The elevations of two stations are 1590 and 1502 feet respectively. If the slope distance between the two stations is 1000 ft. what is the horizontal distance separating them?

b) Two stations differ in elevation by 330 ft and are horizontally separated by a distance of 20 chains. What is the slope distance between the two stations in feet and also chains? (1 chain = 66 ft).

Solutions :

a)



$l^2 = h^2 + d^2$

$h^2 = l^2 - d^2$

$h^2 = (1000\text{ft})^2 - (88\text{ft})^2$

$h^2 = 1{,}000{,}000$ sq ft. - 7744 = 992,256 sq. ft.

$h = \sqrt{992{,}256 \text{ sq ft}} = 996$ ft

b) $l^2 = h^2 + d^2$

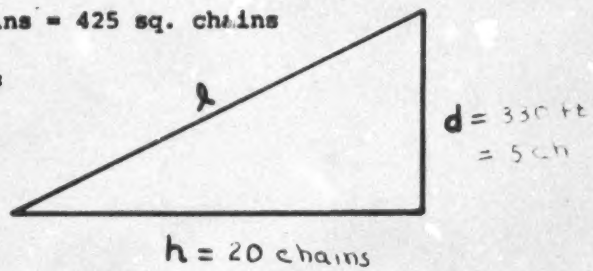
$l^2 = (20 \text{ chains})^2 + (5 \text{ chains})^2$

$l^2 = 400$ sq chains + 25 sq. chains = 425 sq. chains

$l = \sqrt{425 \text{ sq chains}} = 20.6$ chains

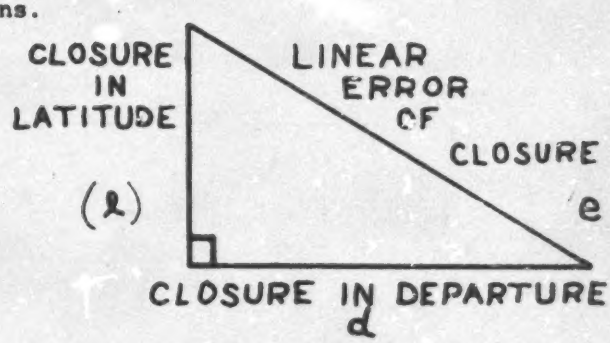
or, $l = (20.4 \text{ ch}) \left(\frac{66\text{ft}}{1 \text{ ch}}\right)$

$l = 1360$ ft



B. Problems without complete solutions.

3. In traverse computations the linear error of closure (e) is the hypotenuse of a right triangle whose sides are the closure in departure (d) and the closure in latitude (l).

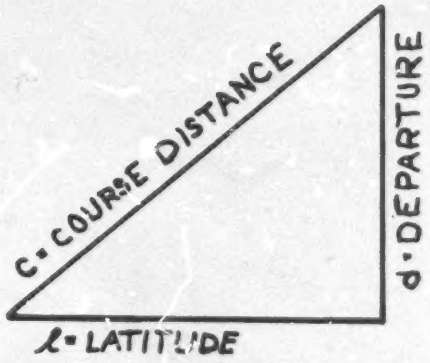


Determine the linear error of closure for the following:

a) closure in departure = .69 ft : closure in latitude = .51 ft

b) closure in departure = .19ft ; closure in latitude = .08ft

4. Using the right triangle in the diagram determine the following:



a) course distance if latitude = 85 ft and departure = 196 ft.

b) departure if course distance = 1300ft. and latitude = 1200 ft.

c) latitude if course distance = 340.3 ft and departure = 114.7 ft.

complete solutions to B problems.

3. Solution:

In each case the pythagorean theorem applies since the triangle is a right triangle so:

$$e^2 = l^2 + d^2$$

a) $e^2 = l^2 + d^2$

$e^2 = (.51\text{ft})^2 + (.69\text{ft})^2$

$e^2 = .2601 \text{ sq ft} + .4761 \text{ sq. ft.}$

$e^2 = .7362 \text{ sq ft.}$

$e = \sqrt{.7362 \text{ sq ft}} = .86 \text{ ft}$

b) $e^2 = l^2 + d^2$

$e^2 = (.08 \text{ ft})^2 + (.19 \text{ ft})^2$

$e^2 = .0064 \text{ sq ft} + .0361 \text{ sq ft.}$

$e^2 = .0425 \text{ sq ft.}$

$e = \sqrt{.0425 \text{ sq ft}} = .21 \text{ ft.}$

4. Solutions:

a) $c^2 = d^2 + l^2$

$c^2 = (196 \text{ ft})^2 + (85\text{ft})^2 = 38416 \text{ sq ft} + 7225 \text{ sq ft} = 45641 \text{ sq ft.}$

$c = \sqrt{45641 \text{ sq ft}} \approx 214 \text{ ft}$

b) $c^2 = d^2 + l^2$

$(1300 \text{ ft})^2 = d^2 + (1200 \text{ ft})^2$

$d^2 = (1300 \text{ ft})^2 - (1200\text{ft})^2 = 1{,}690{,}000 \text{ sq ft} - 1{,}440{,}000 \text{ sq ft.}$

$d^2 = 250{,}000 \text{ sq ft}$

$d = \sqrt{250{,}000 \text{ sq ft}} = 500\text{ft}$

Complete solutions to B problems

4. Solution, continued.

$c^2 = d^2 + l^2$

$(340.3 \text{ ft})^2 = (114.7 \text{ ft})^2 + l^2$

$(340.3 \text{ ft})^2 - (114.7\text{ft})^2 = l^2$

$l^2 = 115804 \text{ sq ft} - 13{,}156 \text{ sq ft}$

$l^2 = 102{,}648 \text{ sq ft}$

$l = \sqrt{102{,}648 \text{ sq ft}}$

$l = 320.4 \text{ ft.}$

SQUARE ROOT
Level 1

Auto Mechanics

A. Problem with Solution

1. The stroke of a 4-153 Chevrolet engine is 3.25". Find the bore of the cylinder.

Definitions:

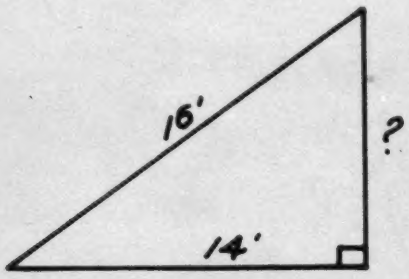
4-153 engine: 4 cylinders and 153 cu in displacement

Solution:

$$\sqrt{\left(\frac{153 \text{ cu in}}{4}\right) \div (3.25 \text{ in}) \div (0.7854)} = 3.875 \text{ in bore of the cylinder}$$

A. PRoblems with Solutions

1. The length of a rafter is 16 feet, and the run is 14 feet. What is the rise?



Solution:

$$\sqrt{(16')^2-(14')^2} = \sqrt{256' - 196'}$$

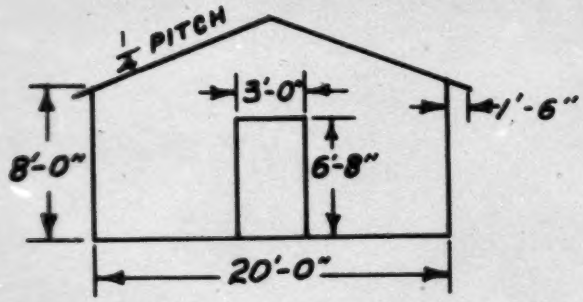
$$= \sqrt{60'}$$

$$= 7\ 3/4'$$

= 7 feet 9 inches rise

B. Problems without Solutions

2. What is the run of the roof rafters in the figure?



Complete Solutions to B Problems

2. $\sqrt{(11'\ 6")^2 + \left(\frac{11'\ 6"}{4}\right)^2}$

$= \sqrt{(138")^2 + (34.5")^2}$

$= \sqrt{(142.25")^2}$

$= 142.25"$

= 11 feet 10 1/4 inches